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16. ABSTRACT

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The cost and effectiveness of compounds formulated play the major role in their adoption. Chlorinated rubber type compounds, while more expensive than other types investigated, had some superior properties which justifies their use on structures. Availability of raw materials and air pollution laws have required some adjustment of composition. Lab tests used to compare performance are not very satisfactory. Alternatives to teh standard mortar pan test method were explored, and a field test to measure spread rate was developed.

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DEVELOPMENT OF CONCRETE CURING PRODUCTS AND PRACTICES

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The authors wish to acknowledge the work performed by the many other engineers and technicians who took part in this study over the years. Since this report includes results from various substudies, the list of participants is large; however, our special thanks go to the late Mr. Herbert Rooney for his guidance in formulation, Messrs. Bill Neal, Carl Sundquist, Lee Wilson, Ben Squires, John Boss, Gary Mann, and Phil Young for their assistance in performing lab and field tests, and last but not least, Mrs. Faye Penrose for her patient assistance in preparation of the report.

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By

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California Department of Transportation

INTRODUCTION

The beneficial effects of good curing are well known[1-6,8,9*]. While compressive strength has often been a criterion for comparison for curing methods, other important factors are involved. For example, craze cracking, plastic shrinkage, and full depth transverse or map cracking are undesirable. This condition may result from delays in application of curing procedures but does not necessarily reduce compressive strength to any significant degree. Some types of cure provide temperature control (sometimes by cooling and sometimes by heating,) to minimize adverse effects. Surface abrasion resistance is a particularly important factor for

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*Note: Numbers refer to specific references listed at the end of this report.

floors and pavements, yet compressive strength tests of cores will not usually reflect surface conditions.

As the need for better surface textures increased, the whole operation of curing and texturing was critically examined to determine areas of possible improvement. Factors such as increased traffic, higher speeds (resulting in need for greater initial and longer lasting skid resistance), earlier use of pavement after construction (and even during construction), and an awareness of lack of texture durability prompted seeking improvements in construction and in materials used to form the texture of the pavement. Upgrading of curing appeared to be a way to help overcome some of the problems caused by loss of surface texture.

Liquid type curing compounds for concrete pavement have been used for a long time, perhaps born from the desire to get away from the messy, more complicated and expensive "water cure" recognized by early concrete technologists as necessary for best results. While liquid type curing membranes are not as effective as wet type curing, they are in many cases, adequate, much lower in cost to use, and more convenient. Maintaining wet mats is both messy and inconvenient. Water supplies must be developed and inspection maintained during the whole curing period. Removal and replacement of mats for sawing operations on pavements requires a considerable amount of extra labor. One significant plus factor, however, is the cooling effect of a wet cure which is important on bridge decks. A small outdoor "laboratory type" test program confirmed the relative effectiveness of the more common types of curing used. Comparing temperatures and compressive strength of concrete cured with a liquid compound, a reinforced plastic sheet and wet mats resulted in the following:

Type of Cure	14-day, % Relative Core Strength	Maximum Temperature* During 1st 24 hours, °F
Wet mats (7 days, then air cured)	100	103
No Cure (allowed to air dry)	56	98
Chlorinated Rubber Type Membrane	77	116
Reinforced Plastic Sheet (7 days, then air cured)	75	110

*1/2-inch below surface. Maximum air temperature on 1st day was 98°F. Ambient temperature during curing period ranged from 58°F to 105°F.

Curing studies have been numerous and it is difficult to say when the idea of a liquid seal first came about. In the late 1950's, asphaltic emulsions were in common use and the concerned ASTM Committee was busy developing a performance specification for "nonbituminous liquid compounds for curing concrete".[2] The 1944 specification for liquid type materials was developed for bituminous type products and other types could not successfully be tested under this specification. Mr. Proudley, in his report to the ASTM committee, stated that "The method of test is of special importance and should be simple, so that almost any laboratory can perform it satisfactorily, and comprehensive so that it will simulate a practical range of field conditions, and finally, the test should be reproducible so that a well equipped laboratory with reasonable care can agree with the findings of other acceptable laboratories, and can repeat the tests on the same material in their own laboratory with only a minor tolerance for test errors."

Although some of these goals have been partially achieved after over 20 years of effort, it seems fair to conclude, based on recent correspondence of the present ASTM subcommittee, that there is yet a lot to do. Development of a generally acceptable test has been painfully slow.

Up until about 1968, the so-called wax or wax/resin type curing compound, pigmented to give it ability to reflect heat and thereby lower concrete curing temperature, was most often used for curing pavements. Considering its cost and effectiveness, it was considered adequate. As the demand for deeper and more durable texture increased, it became evident that some upgrading of the product would be desirable. Some typical properties which were considered deficiencies were the tendency of the wax to crystallize during temperature changes, high pigment settling rates, the fact that the cured "film" did not impart any strength or toughness to the surface at early ages (tracked), and the viscosity characteristics which allowed it to sag or run off the peaks of the deeper textures resulting from switching from burlap drags to brooming.

An early concern developed about use of new and different curing compounds and the increased rate of application. The increased application rate and tougher films suggested a reduction in early skid resistance that could create a slick pavement. In one case, the pavement, after receiving application of a new chlorinated rubber type product, appeared to be slick due to sheen and light reflectance. Skid tests made on one project approximately two weeks after application showed that initial skid resistance was indeed reduced, but because a heavier, deeper texture (brooming) had been used, the initial values did not create any skid hazard. If a heavy application of the new material would be made to a pavement having an initially borderline skid resistance, it could conceivably cause a skid hazard. The newer materials have now been in use for several years with no problem with skid resistance reported. The new curing compounds may be expected to prolong better skid resistance because of the toughness of the compounds and better cures. Laboratory abrasion testing indicated that the new materials could be expected to reduce surface wear. Field testing for skid resistance over a 7-year period however, showed no significant differences among curing compounds for prolonging the period of good skid resistance.

Basically, curing compounds specified were required to meet the performance specifications as defined in the AASHTO Specification M-148. A review of tests on samples from jobs indicated a large variation in performance. No doubt part of the wide variations were the result of test method deficiencies as a number of highway departments had expressed dissatisfaction with the test. So as part of a broader plan, work was initiated to find ways of improving the test procedure. New approaches were explored and the existing test method was modified in an attempt to improve it also. As testing was moved out to the field, we found that even there, problems developed because of inability to accurately measure spread rates. Various procedures were developed in an attempt to improve field measurements.

CURING COMPOUNDS

A search for alternatives to the wax/resin base type compound led to two general types: a resin/varnish type and a chlorinated rubber type. A commercial chlorinated rubber type compound was being marketed for curing concrete to improve durability of surface textures in recognition of a national problem. The commercial product conformed basically to a Federal Specification, TT-C-00800. Its relatively high cost, however, limited its use to structures where, because of physical conditions, a better grade material could be justified. The chlorinated rubber product had good moisture retention properties and, equally important to bridge construction, had good drying and scuff resistance qualities which made it particularly desirable for deck and box girder construction. Typically there is much construction activity on decks and inside box girders as soon as the concrete is hard enough to walk on without damage.

By specification, damaged sealant must be repaired immediately. The chlorinated rubber type seal provided a fairly tough membrane which could take a reasonable amount of "traffic" without damage. Another factor which justifies higher curing sealant cost for structures is the fact that most all of the curing a structure will get during its lifetime is the formal curing it gets the first few days after construction. Because some parts of a bridge are up in the air instead of in contact with the ground, the concrete not only tends to dry out more, but is also deprived of some additional moisture which could be supplied at ground levels.

Applying coatings technology acquired through paint formulation activities, modified chlorinated rubber type compounds were developed which not only retained the desirable physical properties, but also were lower in cost than commercially available products. Even so, the cost of this type of curing compound is still relatively high and is not generally used for curing pavements. Various formulations of chlorinated rubber type compounds were developed to meet other specific needs. For example, a somewhat thixotropic version was developed for use on median barriers and other vertical surfaces. A clear and a gray formulation was developed for use where a white was not wanted for aesthetic reasons. As air pollution rules came into effect, the solvent systems had to be altered to comply.

The solvency and relative evaporation rates of solvents had to be considered since those properties affect the continuity of film, pigment suspension, sag and flow characteristics of the curing compounds. Faster evaporating solvents were required for formulations designed for use on vertical surfaces.

Petroleum hydrocarbon resin base curing compounds, being lower in cost, were developed for use primarily on pavements. While they may not have properties equal to the chlorinated rubber type, they are adequate for the purpose. Generally speaking, a good curing seal which lasts at least two or three weeks is probably all that is necessary since pavements being in contact with the ground and subject to wetting during rainy periods continue to cure indefinitely.

In addition to being tough enough to resist some tire traffic from joint saws and the profilograph, the compound had to be able to remain on the ridges left by broom texturing without running down into the low areas.

Several formulations were devised and lab tested. Alternatives to the resin type were also investigated. For example, a limed tall oil base type was developed that equalled the resin type. Although a specification for this product was used as an alternate to the resin type, it was never made commercially, possibly due to some significant differential in manufacturing cost. An acrylic base product also was formulated. Literally dozens of formulations were made and tested, each succeeding one adopted having slightly better properties than the former. The number discarded however, is formidable.

One difficulty in formulating products like curing compounds, whether supplied by composition or performance specifications, is the changes that can occur in raw materials available. While earlier resins supplied were fairly color stable. later supplies turned quite yellow after a few days exposure to the sun. Of course the specifications can include restrictions on yellowing, but a few "colored" pavements resulted in some adverse comments before being corrected.

Later, materials shortages required many other changes in composition. Formulations involving solvent substitutions required extensive testing as solvent release is a major factor in the formation of impermeable films.

Many combinations of titanium dioxide with various extender pigments and antisettling agents have been tested in an effort to conserve limited supplies of TiO_2 while retaining good reflectance and pigment suspension.

Choice of additives is not indicated in our specifications because the selection is dependent on process variables, e.g., pigment dispersal equipment, which differ among curing compound manufacturers. This policy has occasionally caused problems. As an example, after a new specification was issued, a factory

Sample from one of our curing compound suppliers failed to meet requirements for water retention. The sample complied with all other chemical and physical requirements. Upon investigation, we learned that bentone had been used as an antisettling agent. That addition produced a porous film through which an excessive amount of water vapor was transmitted.

The 1975 Caltrans Standard Specifications will include the following curing compound formulations developed at the Transportation Laboratory:

Specification Number	Nature of Compound	Intended Uses
742-80-71	Pigmented petroleum hydrocarbon resin	General use; chiefly pavements.
741-80-100	Pigmented chlorinated rubber base	Bridge Decks and horizontal surfaces where abrasion resistance during construction is required.
741-80-101	White or gray pigmented chlorinated rubber base	Vertical surfaces, median barriers where nonsagging pigmented finish is desired.
722-80-102	Clear chlorinated rubber base	Colored concrete, exposed aggregate concrete, or where natural color is to be retained.

Lab Testing

and Evaluation

Dissatisfaction with the ASTM and AASHTO Test Methods for measuring moisture loss has been voiced by nearly everyone having to rely on them for product control. Despite the many refinements made over the years, reproducibility is poor, and comparison of results between laboratories is most difficult. Particularly troublesome has been the effect of time of application of the compound to the portland cement mortar, the effect of surface texture, and the difficulty in securing a seal between the mortar and the pan forms. All this could be avoided however, if the general principle of the test were changed; i.e., the compounds should be tested on mortar which is representative of conditions existing in actual use. This argument, of course, has great merit. It, for example, would show up products which might react adversely with the highly alkaline mortar. It also, if texturing is properly carried out, would measure the ability of the compound to remain and protect the higher points, and not run down into the valleys.

One test condition related to equipment requirements is the 32±2% relative humidity (at 100±2°F) specified in AASHTO T-155. While temperature can be readily controlled, relative humidity is another matter and to our knowledge, no equipment is commercially available at reasonable cost that can consistently comply with these requirements. Various studies have been made to isolate the relative effects of test variables and about the only conclusions that can be made is that there are a lot of them. However, as with some other tests, a specific operator can get a "feel" for the test and by careful control, use it successfully. By replicate testing and experience, for example, a defect, such as failure of the seal between the mortar and the pan, will be easily recognized. Operator skill in applying the membrane must be at a high level as the amount of sealant sprayed and method of spraying some materials are critical.

To overcome some of the difficulties and cost of conventional AASHTO testing, other means of evaluation were explored. For example, liquid membranes were applied to filter paper which in turn was used to cap a jar containing water. The loss of water through the coated paper was determined by weighing the jars which were stored in an oven at 137°F. Unfortunately, the test results did not always correlate with moisture losses determined by the AASHTO method. This method, nevertheless, has better repeatability and may be useful in comparing curing products. Some typical test results are shown in Table 1. The tentative test procedure is in the appendix.

Other paper or filter type base materials are still being considered, however, and means of obtaining a uniform reproducible film are being explored.

Another approach investigated was the drawing down of a film of predetermined thickness on a transparent base. After drying the films were examined with a microscope. While not considered suitable for a control test, we did find that wax base or wax/resin base material usually failed the moisture retention test if the dried film appeared sandy or gritty.

Other measures of compound efficiency explored were flexural strength of coated concrete specimens and abrasion resistance. These tests, while a measure of what the curing compound does, are difficult and time consuming to perform and are, therefore, considered unsuitable for routine acceptance testing.

Field Testing

Field testing is generally limited to sampling and determining rate of application. Usually the application rate was checked by counting the number of barrels of compound used over some measured distance and calculating the coverage in square feet per gallon (as specified). This procedure, of course, does not tell us anything about uniformity of coverage, nor does it reflect the amount of compound lost in the wind or overspray. Despite the fact spray rigs are required to have "shields", there are often conditions under which shields are not effective. Some protect the spray only if the wind is from the front or rear. Side winds can carry much of the compound away. To improve the accuracy of measuring compound applied, a procedure was developed to measure the compound at different points on the pavement surface. Absorbent pads were made that were preweighed, then placed at various points in front of the spray rig. Immediately after the sprayer passed, the pads were folded (wet sides together) to prevent loss of weight through evaporation, and then reweighed. Knowing the area of the pad and the gain in weight, coverage could be readily calculated. Some typical results are shown in Tables 2, 3, 4, and 5. These data indicate some rather nonuniform application rates on actual jobs, and point up the inadequacy of a specification calling for a single application rate.

Later, the test method (California 535) called for "Pampers" as the absorbing medium. The test method is included in the appendix. The method required field weighing of the pads which were recovered immediately after application of the compound and sealed in small plastic bags.

While the pad weighing method was shown to be operational, an even simpler test procedure was desired. The use of a wet film thickness gage used in paint inspection was developed. For this procedure, wet films are collected on a metal or glass base and a specially made gage is used to measure the thickness. (See Figure 1.) Rigid paint can lids were substituted for the thicker metal and glass plates which eliminated cleaning of plates. The tentative wet film thickness test method is in the appendix.

Some measurements on the dried film were also made. Theoretically, if the percent solids of the compound is known, the dried film thickness should be directly related to wet film thickness. In the case of one field test, the relationship was not good because the compound was not adequately stirred before use and the actual solids content was low compared to what was specified. Since this was measurable, the test might be used as a gross check on the solvent/solids ratio.

Some skill is required to handle the gage as slight tipping or failure to hold the base flat to prevent flow will cause erroneous results. A magnet fastened to the end of a pole proved to be a simple yet effective means of collecting the plates when placed more than an arm's length in from the edge of the pavement. Such placement is, of course, necessary to check transverse spread rates.

Table 1

A Comparison Between Test Results from Mortar and Water Vapor Transmission Methods

Sample No.	Water Loss at 24 hours, Grams: AASHTO Mortar Method	Water Loss at 24 hours, Grams: Water Vapor Transmission Through Filter Paper
TK-26, gray	10	5.2
TK-26-1	6	3.4
70-006	41	15.2
70-007	21	12.2

SPREAD RATE[a] DETERMINATION OF CURING COMPOUND

Table 2

Laboratory Tests

Actual Spread Rate	Spread Rate Recorded on Test Pads
132	129
132	130
150	145
150	152
200	195
200	220
100	96

(a) Square Feet per gallon

SPREAD RATE[a] DETERMINATION OF CURING COMPOUND

Table 3

Laboratory Tests on

an 8'x18' Concrete Slab

Spread Rate Determined by Volume Method	Spread Rate Recorded on Test Pads
200*	160
	200
	185
	195
	210

* Average for whole slab

(a) Square Feet per Gallon

SPREAD RATE[a] DETERMINATION OF CURING COMPOUND

Table 4

Field Test on 24' Pavement

First Day

Spread Rate Determined by Volume Method	Spread Rate Recorded on Test Pads
123*	310
	310
	242
	165
	235
	235
	225

* For the day's paving

(a) Square Feet per Gallon

SPREAD RATE[a] DETERMINATION OF CURING COMPOUND

Table 5

Field Test on 24' Pavement

Second Day

Spread Rate Determined by Volume Method	Spread Rate Recorded on Test Pads
128	165
98	170
134	195
120	175
---	165

(a) Square Feet per Gallon

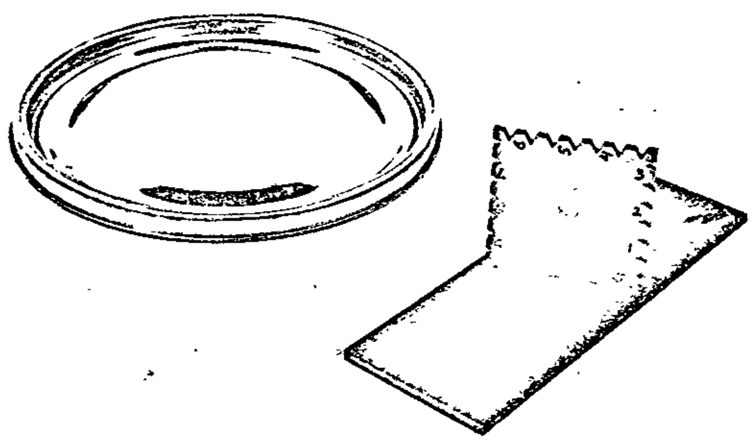

Figure 1

Equipment used for wet film thickness determination

CONCLUSIONS

1. Curing compounds used to cure pavements and structures have been formulated to have better overall properties (i.e., moisture retention, viscosity, sag, and uniformity), than those available in the past. Chlorinated rubber type curing compounds were designed for use on decks and other surfaces where scuff resistance is important, and for use on vertical surfaces where sagging is detrimental. Resin type compounds of lower cost were developed for pavements where long lasting curing seals are not necessary.

2. A moisture vapor permeability test using filter paper as a substrate could be used in lieu of AASHTO T-155 for comparing water retention characteristics of curing compounds. The AASHTO method should be used as a referee procedure until an acceptance limit can be established for each type of material tested.

3. Field tests for determining spread rates of curing compounds at the time of application have been developed. The use of these spread rate methods is effective in encouraging contractors to apply uniform coatings of adequate thickness.

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APPENDIX 1

TENTATIVE METHOD OF TEST FOR MEASURING WATER VAPOR TRANSMISSION THROUGH CONCRETE CURING SEALS

SCOPE

This test method is intended for use in determining the efficiency of liquid membrane-forming compounds as measured by their ability to prevent water vapor transmission.

PROCEDURE

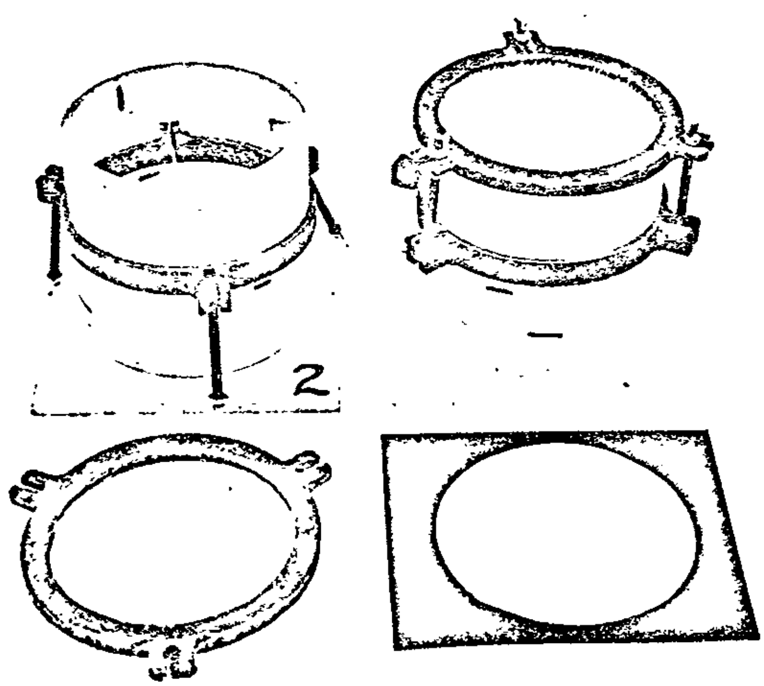
A. Apparatus

1. Balance sensitive to 0.1 gram with a capacity of 3000 grams (the Mettler Model P3 fills this requirement).

2. Suitable wind shield for balance to prevent air currents from causing errors in weighing.

3. Curing cabinet, for curing the specimens, shall maintain a temperature of 100±3°F (37.8±1.7C) and a relative humidity of 30±4%. Air flow shall be sufficient to remove the solvent vapors quickly, but no detectable air current shall strike directly on the surface of any test specimen stored in the cabinet.

4. Cylindrical plastic containers 6-in. in diameter, 6-in. deep, with a 7-1/2-in. sq. x 3/8-in. thick plate firmly and permanently glued to bottom. The cylinder walls shall be 1/4-in. thick. These containers are to be fitted with a metal clamping device (as shown in the figure) and shall maintain the ability to keep the sharkskin filter paper firmly held in place to prevent vapor pressure leakage. This is accomplished by having a lip on the lid cut in 5/16-in. from inside 5/16-in. thick to which a 1/8-in. thick, 1/4-in. wide neoprene gasket glued permanentely to the metal cap. The top lip edge of the plastic container is to have a space age superglue called "Silicone Seal". (It will be necessary to recoat after about every 25th use. This offers a positive nonstick seal.)



5. Sharkskin filter paper, Van Waters and Rogers, Catalogue No. 28314, Code 082.

6. Tube GE Clear Silicone Seal.

7. One 500-ml graduated cylinder.

B. Preparation of Containers for Testing

1. Place 500 mls distilled water in each test container.

2. Carefully place filter paper on top lip of plastic container.

3. Bring lip of cover down slowly so as not to disturb paper.

4. Place swing bolts in slots, tighten wing nuts evenly, but to a firm finger tightness.

5. Place in 100°F oven for about one hour before spraying.

C. Application of Curing Compound

1. Stir sample thoroughly just before spraying making sure there has been no settlement.

2. With a suitable spray gun and correct pressure, spray the entire exposed surface of filter paper, being careful to spray evenly the following amounts:

3. Chlorinated Rubber - 2.0 grams.

4. Resin Base - 2.3 grams.

5. Tare container to nearest 0.1 g and record weight.

6. Reweigh sample immediately after spraying and record weight after correct amount is sprayed on.

7. Prepare and spray three container specimens for each sample tested.

8. Spray an equal amount of compound on a blank sharkskin paper to measure volatile loss.

D. Testing of Treated Specimens

1. After applying compound and reweighing, place the treated specimens along with the treated paper disk in curing cabinet. Cure for 24 hours at 100 ± 3°F and 30 ± 4% relative humidity. Then remove from the curing cabinet and weigh to nearest 0.1 gram.

E. Calculation

1. Calculate the total weight lost by each specimen as the weight of the specimen immediately after applying the curing compound less the weight of the specimen after the 24-hour curing period.

2. Calculate the volatile loss of the curing compound to the nearest 0.1 gram immediately after applying the compound less the weight of the disk after 24 hours in the curing cabinet.

3. Calculate the water loss to the nearest 0.1 gram for each specimen as the total weight lost by the specimen less the volatile loss of the curing compound calculated to the nearest 0.1 gram.

4. A tentative pass or fail net loss of 2.0 grams with an allowable tolerance of ±0.3 gram has been set for this test.

F. Precautions

1. Spray only under vented hood.

2. Avoid prolonged breathing of compound or solvents used to clean spray gun.

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METHOD OF TEST FOR DETERMINING APPLICATION RATE OF CONCRETE CURING COMPOUND IN THE FIELD

Scope

This test method, an adaptation from Test Method No. Calif. 339, describes the procedure for determining the rate at which concrete curing compound is applied to portland cement concrete pavements.

Procedure

A. Apparatus

1. Balance, accurate to 0.5 gram, or less, and having a capacity of about 200 grams.
2. Suitable weighing box or wind shield for balance.
3. Stop Watch
4. Specific gravity bottle (25 to 100 ml. capacity), or hydrometer (range about 0.90 to 1.10 specific gravity).

B. Materials

1. Disposable diapers, absorbent pad with waterproof backing, 12½" x 16" (Daytime Pampers, Procter and Gamble or equal).
2. Plastic sheet, .040" thick by 11" x 15". This may be cut from sheet plastic, Template material, cellulose acetate, Division of Highways Service and Supply No. 17246.
3. Sack-plastic polyethylene 9" x 15", 100 per pkg. with ties, Division of Highways Service and Supply No. 69663.

C. Preparation of Test Pads

1. Form test pad by trimming edges of waterproof backing to match dimensions of absorbent pad. (Do not detach pad from backing). Discard trimmings.
2. Weigh each test pad together with a plastic sack to the nearest gram, to establish tare weight.
3. Insert 11" x 15" plastic sheet between absorbent pad and backing in order to keep pad flat and prevent its being blown aside or turned over by wind or spray.

D. Sampling and Weighing

1. Longitudinal Distribution. Place 5 test pads, with absorbent face up, along the pavement approximately 3 feet from the edge at random intervals (7–13') over a 50 foot length ahead of the spray rig: (See figures I and II).
2. Transverse Distribution. Where fixed nozzles on a distributor bar are used, it is desirable to determine transverse distribution. Place 5 test pads absorbent face up, at random intervals across the slab or under nozzles which appear to be delivering at abnormal rates. Place test pads on the pavement and remove them without stepping on newly placed concrete. Observe whether the curing compound is being applied at its normal rate at the time the spray equipment passes over the test pads.
3. As soon as the spray rig has passed, remove each test pad from the pavement. Wipe off any adhering moisture, curing compound or mortar from the waterproof backing.
4. Remove plastic sheet and save for reuse. Fold absorbent pad inside its waterproof backing and place in plastic sack. Tie opening of bag firmly to prevent loss of volatiles. Complete this operation within two minutes after application of curing compound to the test pad.
5. Weigh each test pad in its plastic bag as quickly as possible to the nearest gram. (Consider the test invalid unless the weighing operation is completed within one hour after removing the test specimen from the pavement.) Record as "final weight."

E. Calculations

1. Calculate the total weight of curing compound applied to each test pad as the final weight less the tare weight. Read the nominal application rate in square feet per gallon from Table I. Calculate the actual rate of application, (corrected for specific gravity of compound if different from 1.00), by multiplying the rate from Table I by the specific gravity of a well mixed representative sample of the curing compound. (If possible, this sample should be taken from a spray nozzle or from the feed line to the spray nozzle. The specific gravity shall be determined by means of a suitable pycnometer or hydrometer.)
2. Calculate the average application rate in square feet per gallon, as the sum of the individual corrected rates divided by five.

F. Notes and Precautions

1. Weigh the wet test pads as soon as possible to reduce errors caused by loss of volatiles.
2. By means of a stop watch, time the rate of advance of the spray equipment over several fifty foot sections to establish the average time of travel for fifty feet. Then check the time taken to spray the test section by the same method to determine if the spray equipment operator maintains the same forward speed. Similarly, read the pressure gauge on the spray equipment during normal operation and when compound is applied to the test section. If the time of travel or pressure varies more than 10% from the average, consider the tests invalid and repeat the test.
3. Shield test pads placed near the edge of the pavement slab from overspray from nozzles applying compound to the exposed edge of slip-formed pavement.
4. A test pad may be placed at some distance from the edge of the pavement and later removed by using a pole or lath.

REFERENCES

Test Method No. Calif. 339

End of Text on Test Method No. Calif. 535-B

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TABLE I

CONVERSION TABLE

Net Weight of Curing Compound on 12½" x 16" Test Pads to square feet per Gallon

Net Weight of Curing Compund on Test Pads, Grams	Nominal Appl. Rate, Square Feet per Gallon	Net Weight of Curing Compound on Test Pads, Grams	Nominal Appl. Rate, Square Feet per Gallon
10	504	30	168
11	458	31	163
12	420	32	158
13	388	33	153
14	360	34	148
15	336	35	144
16	315	36	140
17	296	37	136
18	280	38	133
19	265	39	129
20	252	40	126
21	240	41	123
22	229	42	120
23	219	43	117
24	210	44	115
25	202	45	112
26	194	46	110
27	187	47	107
28	180	48	105
29	174	49	103
		50	101

Approximate Rate of Application-Sq.ft/gal, based on actual measured test pad area 12" x 16" (nominal 12½" x 16") assuming a specific gravity for curing compound of 1.00. For specific gravity different from 1.00, multiply "application rate" from Table, times the actual specific gravity of the compound.

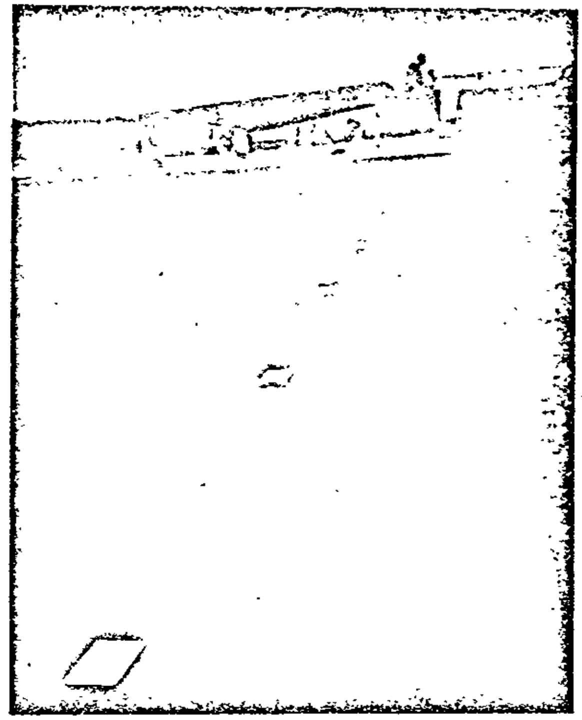

FIGURE II

Test Pads in Position for Test

FIGURE I

Placing Test Pads on Pavement

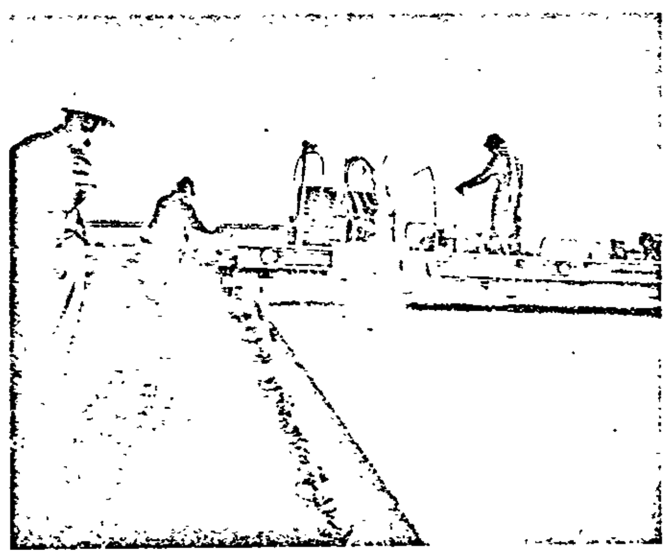

FIGURE III

Spray Equipment Passing Over Test Pads

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APPENDIX 3

TENTATIVE METHOD OF TEST FOR DETERMINING SPREAD RATE OF CURING COMPOUNDS BY WET FILM THICKNESS TEST

SCOPE

This test method is intended for use in determining the spread rate of curing compounds in the field as measured by the wet film thickness of curing seals.

The gage reads to the nearest 0.5 mil. Through precalculated charts, gage reading is directly converted to indicate coverage in square feet per gallon.

PROCEDURE

A. Apparatus

1. Gallon bucket lids, heavy duty T.P. 51, E-Z Pry. The lids can be purchased from General Can Company, 274 Bannon Street, San Francisco, CA 94107, Telephone (415) 781-2652.

2. 6-in. by 6-in. smooth finish thin steel plates. (Note: One plate should last for one day's testing.)

3. 1/2-in. by 1-in. by 6-in. magnet (with sufficient magnetic attraction to pick up and hold firmly gallon bucket lid along with steel plate.)

4. 2-in. by 2-in. by 1/8-in. stainless steel gage that is graduated to read from 0.5 mils to 12.0 mils in 0.5 mil increments.

Note: This gage is manufactured by the Caltrans Transportation Laboratory, 5900 Folsom Boulevard, Sacramento, CA 95819.)

5. A 5/8-in. by 60-in. round dowel with cup hook screwed into one end, or when not available, use small nail driven into one end of a 4-ft. lath.

6. One Red 1-gallon can to store toluene; 1 quart can or other convenient dispensor to hold toluene for cleaning gage.

7. Supply of toluene or other solvent that will cut whatever compound is being used.

8. Disposable medical gloves (vinyl); Tru-Touch made by Bard-Parker is one source. (Note: These gloves are inexpensive and are very valuable as toluene is very irritating to the skin.)

9. Supply of rags for cleaning.

B. Preparation for Testing

1. Wait until water sheen has left surface and final drag is complete. Then carefully place bucket lid on surface. Use a long survey marker or other stick to lift lids out beyond arm's reach.

2. Have dowel, with cup hook attached to wire that holds magnet, and 6-in. plate near by so that lid can be retrieved immediately after spray rig passes over. Bring magnet down evenly to insure that lid is not tilted when contact is made.

C. Testing Sprayed Lid

1. Hold as evenly as possible to insure that curing seal will not run to one side.

2. Grasping bottom of lid firmly with one hand, slide top plate off being careful not to disturb sprayed surface.

3. Holding lid as level as possible with one hand, press down evenly but firmly with other hand (do not allow gage to slide). The last marker that shows white or when using clear, the last marker that shows wet, will be the correct reading. Take an average of five readings as the film thickness. These five readings should be taken within 60 seconds after retrieval.

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D. Calculation

1. Use precalculated coverage conversion chart to read the indicated coverage that is directly opposite the average gage reading.

E. Precautions

1. Use vinyl plastic gloves.

2. Clean gage after each reading by wiping quickly across cloth rag.

3. Clean gage thoroughly with solvent after each test, as a slight amount of buildup of residue can adversely affect the next test.

4. Avoid breathing of strong solvents as much as possible.

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WET FILM THICKNESS TEST

COVERAGE INDICATOR CHART

Wet Film Gage Reading	Coverage Sq.Ft./Gal.	Wet Film Gage Reading	Coverage Sq.Ft./Gal.
3.90	420	6.00	270
3.95	410	6.20	260
4.05	400	6.50	250
4.15	390	6.70	240
4.30	380	7.00	230
4.40	370	7.50	223
4.50	360	8.00	207
4.60	350	8.50	190
4.80	340	9.00	180
4.90	330	9.50	170
5.00	320	10.00	160
5.20	310	10.50	155
5.40	300	11.00	147
5.50	295	11.50	144
5.60	290	12.00	136
5.80	280		